~~SECRET~~

CONFIDENTIAL

SECRET

DELAY ACTUATOR SILICONE

SECOND SUMMARY REPORT

183 E ON CONFIDENTIAL

TASK ORDER NO. J

February 28, 1959

25X1

Sanitized Copy Approved for Release 2011/09/20 : CIA-RDP78-03639A001300080001-2

TABLE OF CONTENTS

LIST OF FIGURES

SECOND SUMMARY REPORT

ON

TASK ORDER NO. J

February 28, 1959

INTRODUCTION

During the past several years, a search by many organizations for a cheap, reliable, and reasonably accurate time-delay mechanism has led to the consideration of silicone fluid as a timing medium. The Sponsor has had developed a time-delay device based on the extrusion of silicone fluid through an orifice; but, the operating range of this device was limited because of the changes in viscosity and volume of the fluid that resulted from changes in temperature and pressure. On January 8, 1957, Task Order No. J was undertaken, to develop suitable temperature and pressure compensators that could extend the use of time-delay units using silicone fluid.

As indicated in the "Summary Report on Task Order No. J" dated October 31, 1957, basic design criteria were established for a temperature compensator that would consist of two orifices. One would be a simple circular-cross-sectioned port; the other would be a temperature-compensating orifice formed by the annular space between two components made from selected materials having different coefficients of thermal expansion. Variations in temperature would affect the size of the annular orifice and thus the flow through it. With an increase in temperature, the viscosity of the fluid would decrease and, consequently, the flow rate through the simple circular-cross-sectioned port would increase. The flow rate through the annular orifice, however, would decrease with increasing temperature if the materials for the orifice-forming parts were selected so that the orifice size would be reduced rapidly with an increase in temperature. The results obtained with an experimental temperature-compensating unit of this type were not perfect; but, significant compensation was achieved, and it appeared that a more considered selection of materials and component sizes could result in adequate temperature compensation.

In a proposed program of research transmitted with our letter dated January 17, 1958, a further effort was described that was expected to make possible the subsequent preparation of an experimental model of a satisfactory time-delay unit. It was proposed that combinations of sizes and materials for the components of the temperature-compensating device be investigated, selected, and evaluated under laboratory conditions; and an experimental model of a complete time-delay mechanism be prepared and evaluated. This report describes the results of the effort performed in this connection under Task Order No. J, during the period November 1, 1957, through February 28, 1959.

SUMMARY

The activity on the extension to the original Task Order No. J program began with the investigation of the optimum orifice-annulus combination for the temperature-compensating mechanism of the proposed timer. A study was made of different materials which might be used to form an

annulus of the type needed. After appropriate materials had been selected, theoretical curves were drawn for the rate of flow through different-sized orifices and annuli (formed by combinations of these materials) at temperatures from -20 to 120 F. On the basis of these curves, it was decided that a proper orifice-annulus combination could be selected by means of the graphic combination of selected curves. The subsequent effort showed that, if at -20 F the orifice diameter was 0.0218 times the inner diameter of the steel-cylinder portion of the annulus and the annulus radial clearance was 0.0048 times the cylinder inner diameter, then the combined flow rate through both ports would remain constant within ±2-1/2 per cent over a temperature range of -20 to 120 F. In view of the required accuracy of ±10 per cent for the desired mechanism, the theoretical design based on the above dimensional relationships looked very promising.

A laboratory model of a silicone-fluid timer was designed that incorporated the orifice-annulus relationship as calculated. The design also included the other basic components necessary to achieve proper flow during the time range of interest. The design configuration of the unit was such that most of the problems related to the control of flow in the proposed timer seemed to be solved. When the evaluation tests of the laboratory model at -20, 50, and 120 F showed a flow-rate variation of ±14 per cent, the results were judged to be good enough to provide a basis for the design and preparation of an experimental model of a complete timer.

The experimental model designed was very similar to the laboratory model except that it incorporated a firing-pin mechanism and a method of adjusting the size of the annulus radial clearance for experimental purposes.

The experimental model looked very promising. A few cursory evaluation tests were made and it was found that the plastic-plug portion of the annulus had become deformed. It was not possible to make any modifications or to investigate the possible sources of trouble, because of the lack of funds.

Subsequently, a much simpler silicone-fluid-timer development was undertaken under Work Order No. IX, Task Order No. CC. The results of this work were expected to be applicable to the Task Order No. J experimental timer and to provide a meritorious basis for the further investigation of that unit.

ENGINEERING ACTIVITY

This additional effort under Task Order No. J consisted essentially of the determination of an optimum annulus-orifice relationship; the fabrication and evaluation of a laboratory model of a timing device incorporating this relationship; and the fabrication and evaluation of an experimental timer incorporating not only the annulus-orifice relationship, but also the other parameters of interest. Before the work done is discussed, however, a brief review is given of the previous research under Task Order No. J.

Review of Previous Effort Under Task Order No. J

As described in the original proposed research program transmitted with our letter dated November 28, 1956, the objective of Task Order No. J was to develop further a time-delay mechanism which used a silicone fluid as the timing medium, so that it would meet the following specifications:

(1) It should have a high degree of reliability, of the order of 99 per cent.

(2) It should be accurate to within ±10 per cent of the time setting.

(3) It should retain its accuracy over a temperature range of -20 to 120 F.

(4) It should be adjustable over the time range of 15 minutes to 2 months.

(5) It should not weigh more than 1/2 pound.

(6) It should not cost more than $10 per unit in production lots of 10,000.

(7) It should not be larger than about 1 inch in diameter and 4 inches in length.

Because information on the properties of silicone fluids was not readily available, current periodicals and representative manufacturers of silicone products were consulted. As the result, the compound selected for study was Viscasil 500,000, a silicone fluid with a relatively flat viscosity-temperature curve, and with a viscosity which could be changed by selective blending. For the experimental work, three temperature compartments were fabricated from used refrigeration units, to operate at -20, 50, and 120 F. These units were able to maintain temperatures within ±3 F when the ambient temperature was about 70 F.

The ratio of the times for the longest and shortest periods of delay was quite large, namely, 6,000 to 1, over the temperature range of -20 to 120 F. This necessitated a means for adjustment of the pressure to be applied to the fluid. Further, to maintain a calculated flow rate over the temperature range of interest, it was necessary to devise an automatic temperature compensator. Both of these requirements were obviously quite interrelated; it was apparent that a working timing mechanism could not be evolved without careful mutual consideration of both.

Three promising ideas for a timing mechanism were subsequently evolved. One utilized the annular space between two concentric cylinders of different materials as an orifice. If the temperature changed, the size of this orifice would vary, thus altering the flow rate so as to compensate for the temperature-related change in the viscosity of the silicone fluid. Unfortunately, with such a device, the error in timing would probably be greater than the allowable ±10 per cent over the pertinent temperature range. For this reason, the idea was set aside.

The second idea was based on the use of two fluids for two different time ranges, namely, 15 minutes to 20 hours, and 20 hours to 60 days. This idea was sound theoretically and also from many practical aspects. However, the main disadvantage of a corresponding device was the need for either handling the highly viscous fluids in the field or providing essentially two separate units for the two time ranges. Consequently, this idea was abandoned.

The third idea involved a device with selected concentric springs which could be used with any one of seven ports to provide 14 different time delays; associated with such a device might be a temperature compensator, consisting essentially of a sleeve which might be automatically actuated by a bimetal spring so as to change the length of the ports when the temperature changed. In an exploration of this idea, flow-rate measurements through typical ports were made, and an experimental unit was fabricated and evaluated. Unfortunately, the forces in the Viscasil film between the sleeve and the main body, together with the ice formed on the parts at low temperature, prevented this type of temperature compensator from working properly.

Toward the end of the original contract period for Task Order No. J, an idea was conceived for a temperature compensator that appeared to show considerable merit. The corresponding design included two orifices. One was a temperature-compensating orifice formed by the annular space between two concentric cylinders of different materials, such as steel and plastic; the other was a simple circular-cross-sectioned port. A model of this type of temperature compensator was prepared and cursorily investigated; the limited data obtained showed a variation in design flow rate of less than ±10 per cent over the temperature range of -20 to 120 F. Because there were insufficient time and funds to permit a thorough investigation of this idea, it was proposed that Task Order No. J be extended contractually to provide for performing this investigation and developing an experimental working model of the entire timing mechanism. This arrangement was set up and the effort was subsequently performed, as described in the following.

Temperature-Compensator Design

As previously indicated, the annulus-orifice type of temperature compensator was expected to maintain a relatively constant flow rate, for example, during an increase in temperature, by the combination of two effects: (1) an increase in the rate of flow through a constant orifice as a result of a decrease in viscosity, and (2) a decrease in the rate of flow through an annulus which would decrease in area faster (and thus restrict the flow) than the rate of flow through it would increase because of a decrease in viscosity. The two types of ports would be arranged to operate in parallel, in the expectation that the combined flow rate would remain relatively constant despite changes in temperature.

Calculations were made to determine the best annulus-orifice relationship. These were based on the following basic equations:

Flow through a round orifice:

$$Q = \frac{\pi \Delta p a^4}{8 \mu \underline{l}}$$

Flow through an annulus:

$$Q = \frac{\pi \Delta p b^3 a_o}{6 \mu \underline{l}}$$

where:

Q = flow rate, cubic inch per second

Δp = pressure, psi

a = radius of round orifice, inch

a_o = mean radius of annulus, inch

b = radial clearance of annulus, inch

$\underline{l}$ = length of orifice or annulus, inch

μ = viscosity, second per cubic inch.

By letting $\Delta p = 1$, $a_o = 1$, and $\underline{l} = 1$, these two equations were simplified to:

$Q = K_1 \frac{a^4}{\mu}$, for a round orifice; and $Q = K_2 \frac{b^3}{\mu}$ for an annulus where K_1 and K_2 were constants.

On the basis of these simplified equations, calculations were made for the rate of flow of Viscasil 500,000 through several orifice sizes over a temperature range of -20 to 120 F. As shown in Figure 1, an increase in orifice size resulted in a disproportionately larger increase in flow rate than did a large increase in temperature. Thus, as a result of using a small orifice, only a small amount of correction would be needed from the annulus.

The rate of flow of Viscasil 500,000 through different-sized annuli was also calculated. In order to do this, however, it was necessary first to select the two materials which would be used for the parts forming the annuli. Because a reduction in annulus area was sought when the temperature was increasing, it was required that the material of the plug have a coefficient of thermal expansion substantially greater than that of the outer-cylinder material. Steel was selected as the outer-cylinder material because of its low coefficient of expansion, good machinability, resistance to corrosion (in selected compositions), and low cost.

As a part of the previous preliminary work on the annulus-orifice temperature compensator, a brief survey had been made of materials with a high coefficient of thermal expansion that could be used in conjunction with steel in this application. A linear polyethylene plastic known as Mylar had been selected and used in the experimental model which had been prepared and evaluated. In the current effort, additional work was done in an attempt to find other applicable materials; but, after a reasonable amount of effort had been expended, Mylar was still considered to be the best material available. It not only has a high coefficient of thermal expansion, but also

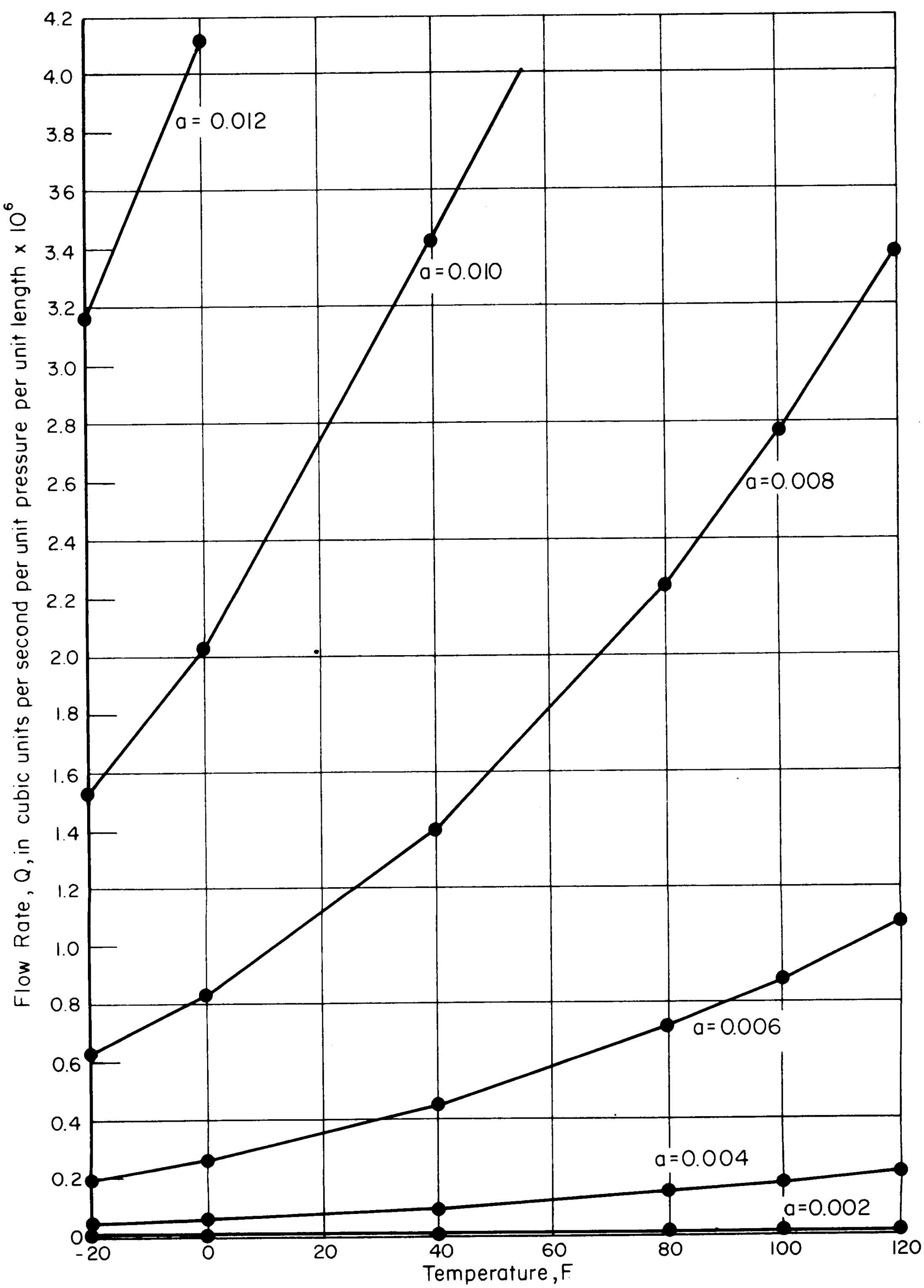

FIGURE I. THEORETICAL CURVES FOR FLOW OF VISCASIL 500,000 THROUGH DIFFERENT-SIZED ROUND ORIFICES is not greatly affected by the presence of moisture and has good machinability. In addition, one of its assets in this application was that its pertinent properties were known.

Figure 2 shows the calculated rate of flow of Viscasil 500,000 through an annulus formed by a Mylar plug and a steel cylinder, for different initial radial clearances over the temperature range of -20 to 120 F. An inspection of the curves shows that, under these conditions, a reduction in flow rate can be obtained only by using a radial clearance which is small at -20 F.

An inspection of curves similar to those shown in Figures 1 and 2 revealed that for small orifices and for annuli with small radial clearances, the flow-rate curve of one type of port seemed to be almost the reverse of that of the other. This led to the conclusion that the proper orifice-annulus combination could be uncovered graphically by finding curves for a particular orifice and for an annulus with a particular radial clearance at -20 F that would be identical when one of the curves was reversed. Appropriate curves were plotted for each type of port; a pair of curves was then selected, one from each category, that appeared to satisfy this criterion. These curves corresponded to an orifice with a diameter 0.0218 times the cylinder inner diameter at -20 F, and an annulus with a radial clearance 0.0048 times the cylinder inner diameter at -20 F. These two curves are shown in Figure 3. The theoretical variation of flow rate was within ±2-1/2 per cent of the mean value from -20 to 120 F. Thus, the theoretical basis was established for a temperature compensator which was expected to be accurate, simple, and reliable.

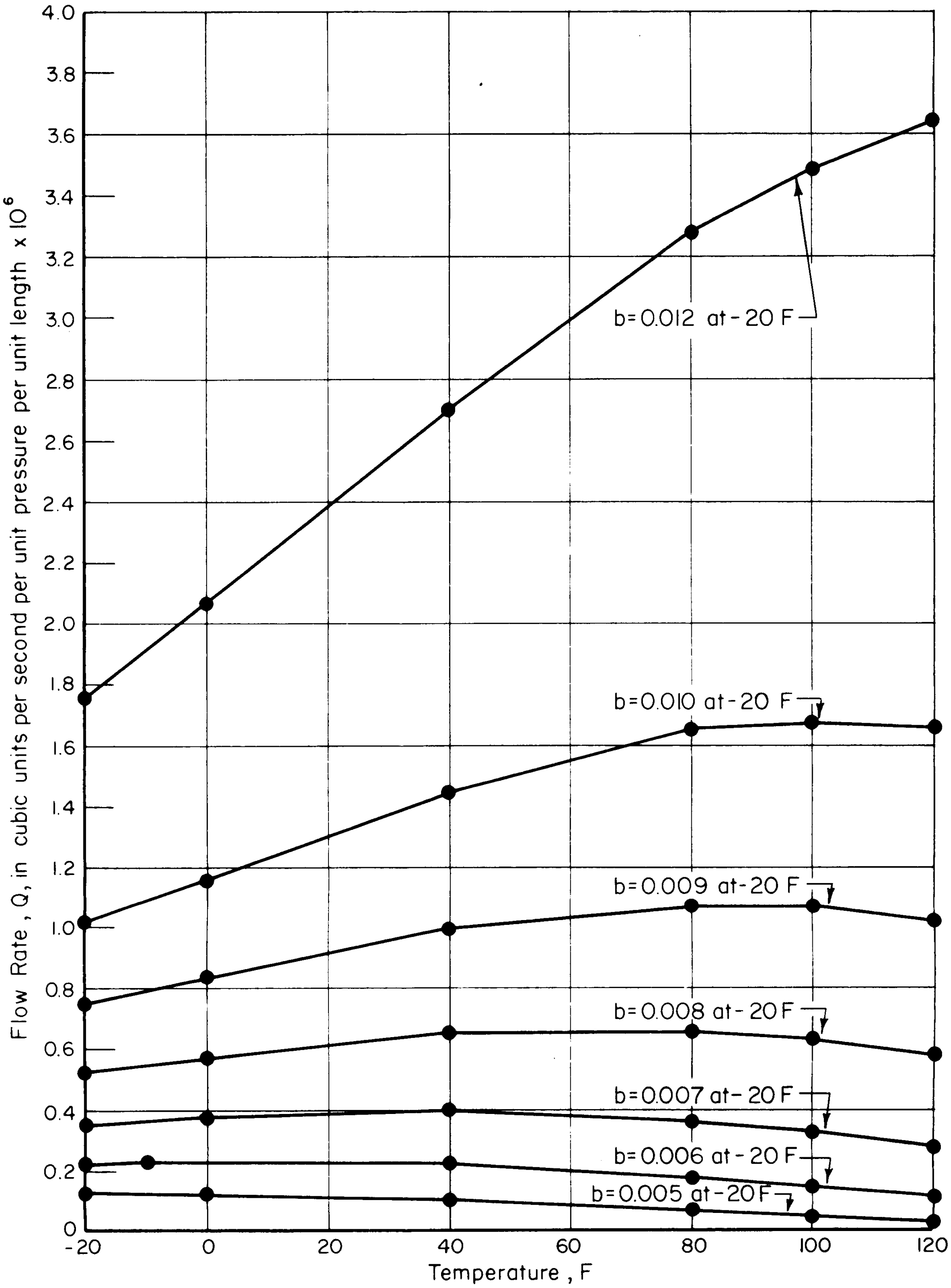

FIGURE 2. THEORETICAL CURVES FOR FLOW OF VISCASIL 500,000 THROUGH ANNULI WITH DIFFERENT INITIAL RADIAL CLEARANCES (FORMED BY MYLAR PLUG AND STEEL CYLINDER)

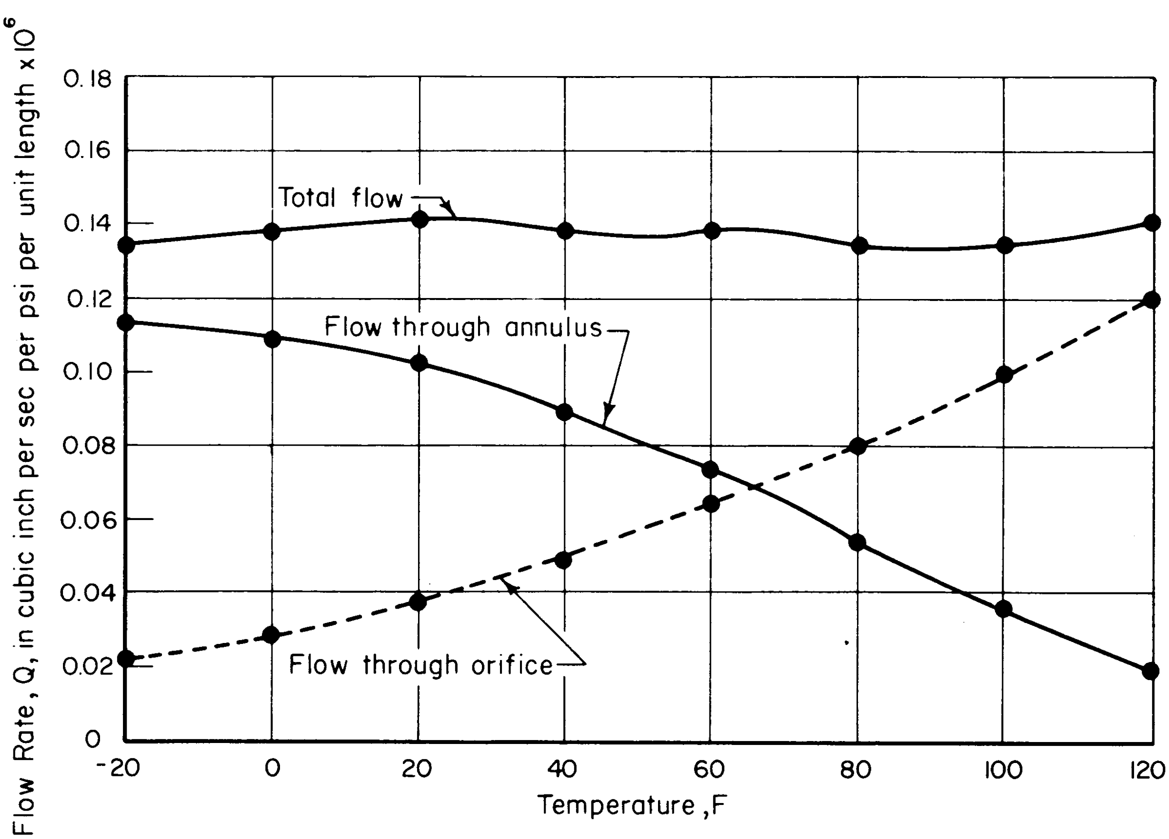

FIGURE 3. THEORETICAL FLOW RATE FOR SELECTED OPTIMUM COMBINATION OF ORIFICE AND ANNULUS

In the initial calculations, the lengths of both the annulus and the orifice, as well as the mean radius of the annulus, were taken as 1. Since the maximum outside diameter of the desired timer was limited to 1 inch, it was necessary to re-consider the above proposition with the size of the annulus reduced.

The effect of reduced dimensions on the flow-rate characteristic can be seen from the equations for flow. Again, the flow equation for a round orifice is:

$$Q = \frac{\pi \Delta p a^4}{8 \mu \underline{l}} \text{ or } \frac{\pi \Delta p}{8 \mu} \times a^4 \times \underline{l}^{-1}.$$

Let us consider the effect of a mutually proportional reduction in the dimensions of the round orifice, i.e., in dimensions $\underline{a}$ and $\underline{l}$. Since $\underline{a}$ appears in the equation to the fourth power and $\underline{l}$ to the -1 power, the resulting change in flow rate would be to the third power.

The flow equation for the annulus is:

$$Q = \frac{\pi \Delta p b^3 a_o}{6 \mu \underline{l}} \text{ or } \frac{\pi \Delta p}{6 \mu} \times b^3 \times a_o \times \underline{l}^{-1}.$$

As with the round orifice, a mutually proportional reduction in the annulus dimensions would result in a third-power change in flow rate.

Since both the annulus and the orifice flow rates would change proportionally with mutually proportional changes in the respective dimensions, it appeared that it would be possible to increase or decrease the size of the timing unit without losing the relatively constant flow-rate characteristic obtainable from an optimum combination of annulus and orifice.

Problems in the Design of a Silicone-Fluid Timer

There are several major problems involved in the design of a satisfactory silicone-fluid timer. A brief review of these is presented below, as an aid to the Sponsor in gaining an understanding of the designs developed for the laboratory model and subsequently for the experimental model.

Size

One major problem is the small size of the timer in relation to the two-month-operation requirement. Essentially, size is determined by the amount of fluid which has to be extruded through the regulating device for a given unit of time. The greater the appropriate quantity of fluid, the greater must be the fluid reservoir and the spring stroke. The required quantity of fluid can be kept small by using a fluid with a high viscosity, a small port cross-sectional area in the regulating device, a long passage in the regulating device, and a low spring force. Each of these is discussed briefly below.

Viscosity. The effect of an increase in viscosity in reducing the rate of flow is obvious from the above-indicated equations. However, there is a practical limit to the extent to which viscosity can be exploited in this application, because of associated manufacturing problems. For example, the timing device, when ready for service, must be selectively free from air, i.e., there should be no air entrapped in the fluid; otherwise, the operation of the device is likely to be unreliable. With a highly viscous fluid, the problem of filling small passages in a mechanism becomes quite rigorous.

It is realized, of course, that the fluid could be heated so that it would flow more freely. However, from a practical viewpoint, it was not considered tolerable to utilize a fluid with viscosity so great that the manufacturing operations would be difficult and expensive.

Port Cross-Sectional Area. An examination of the above-indicated equations shows that the flow rate varies as the fourth power of the round-orifice radius and as the cube of the annulus radial clearance. Thus, the use of small openings would be very effective in keeping the size of the over-all timer reduced; fortunately, the appropriate degree of smallness was in accord with the requirements of temperature compensation for the device, as already described. Also, in view of the relationship of the flow rates to the dimensions, the ports cannot be so small that dimensional variations which are within the manufacturing tolerances might affect the accuracy of the timer. Thus, the type of port, the method of machining, and the resulting accuracy achieved in the port-area "dimension" are factors which limit the amount of area reduction that can be utilized practically.

Port Length. As is also shown by the flow equations, the flow through an orifice and an annulus varies in inverse proportion to the length of the ports. Although some reduction in over-all size can be effected by an increase in port length, again it is considered that the limit would be established by manufacturing tolerances. There is no problem in achieving accuracy of the port-length dimension. However, it would be difficult to maintain the port cross-sectional areas accurately over the entire length of each port; depending on the type of port and the materials used, this problem could be quite rigorous.

Spring Force. A low flow rate can be achieved by using a low spring force. The limiting factors in this regard are the length of stroke and the force needed at the end of the stroke in order to actuate the firing pin. In addition, the theoretical minimum spring force established by these parameters must be increased substantially to insure against the sticking of moving parts in the device.

Operating-Time-Delay Ratio

The ratio of the longest to the shortest operating time delays desired in the proposed timer is extremely high, 6,000 to 1. Furthermore, it must be possible to set the timer so that it will operate at any of several pre-selected small time increments within this range. The problems of achieving this range in a reliable, small, inexpensive mechanism are formidable; the need for providing for quick, simple adjustment of the time delay within the desired range adds complications.

Fluid-Chamber Integrity

A substantial part of the adjustment problem is related to the need for maintaining a sealed fluid chamber. If the operator had to break the seal of the fluid chamber in order to make an adjustment, there would always be the possibility that some of the fluid would be lost or contaminated, and, as a result, the timing accuracy would be affected unfavorably. On the other hand, if all of the adjustment had to be confined to parts external to the fluid chamber, it would appear that only the springs were available as a means of adjustment. While considerable adjustment can be attained in the springs, nevertheless the design of a spring mechanism with a 6,000-to-1 adjustment provision would be difficult, if not impossible, in view of the proposed-timer specifications.

Sliding Parts

The extrusion of the fluid from a reservoir would seem to require some type of sliding seal on the appropriate sliding part. A sliding seal generally introduces inaccuracies, because of the variable friction of the seal; the provision of a seal in a highly viscous fluid represents an even more rigorous situation.

Although an answer to the seal problem was found fairly readily as indicated below, it was extremely difficult to accomplish the proposed action without having sliding parts in contact with the silicone fluid. As described previously, a design with only one sliding part had been explored and it did not work properly. Thus, it appeared likely that a successful timer would probably have no sliding parts in contact with the fluid.

Laboratory Model of Silicone-Fluid Timer

Design

After the basic design of a temperature compensator which appeared to be satisfactory had been determined theoretically, it was necessary to incorporate the pertinent principle in a laboratory unit which would permit a practical evaluation. To obtain reliable data, however, it appeared necessary that the laboratory-model timer have the same basic configuration as was anticipated for the subsequent experimental model, particularly in regard to the components related to fluid flow. After considerable thought, the unit shown in Figure 4 was designed, and subsequently fabricated.

Essentially, the design consisted of one, or possibly two concentric, adjustable springs pushing against a rubber boot which contained the silicone fluid. As the fluid was extruded, the boot rolled inside itself and no sliding seal was required; such boots are commercially available. The fluid was extruded through a common port to either one of two sets of ports. One set, consisting of a short orifice and annulus, provided for a short-time range, and the other set, consisting of a long orifice and annulus, provided for a long-time range. Either set could be selected for use by positioning the valve slide against the timer body as shown in Figure 4, or by moving it along the steel sleeve in the opposite direction; as illustrated in Figure 4, the laboratory unit would provide a long-time delay. An intermediate setting of the valve slide would prevent any flow.

It will be noted that none of the possible selections of valve-slide position would lead to a break in the seal of the silicone-fluid chamber or a change in the volume of the chamber. In addition, except for the valve slide, no sliding parts were in contact with the fluid.

All aspects of this design were either standard or simple and relatively inexpensive to prepare, except for the outside diameter of the plastic plug, the inside diameter of the steel sleeve, and the round orifice. Calculations showed that the plug and sleeve dimensions had to be held within ±.00015 inch on the 0.625-inch diameter. For the .0136-inch-diameter orifice, consideration was given to the use of a hypodermic needle, but the proper placement of such a needle within the unit appeared to be somewhat difficult.

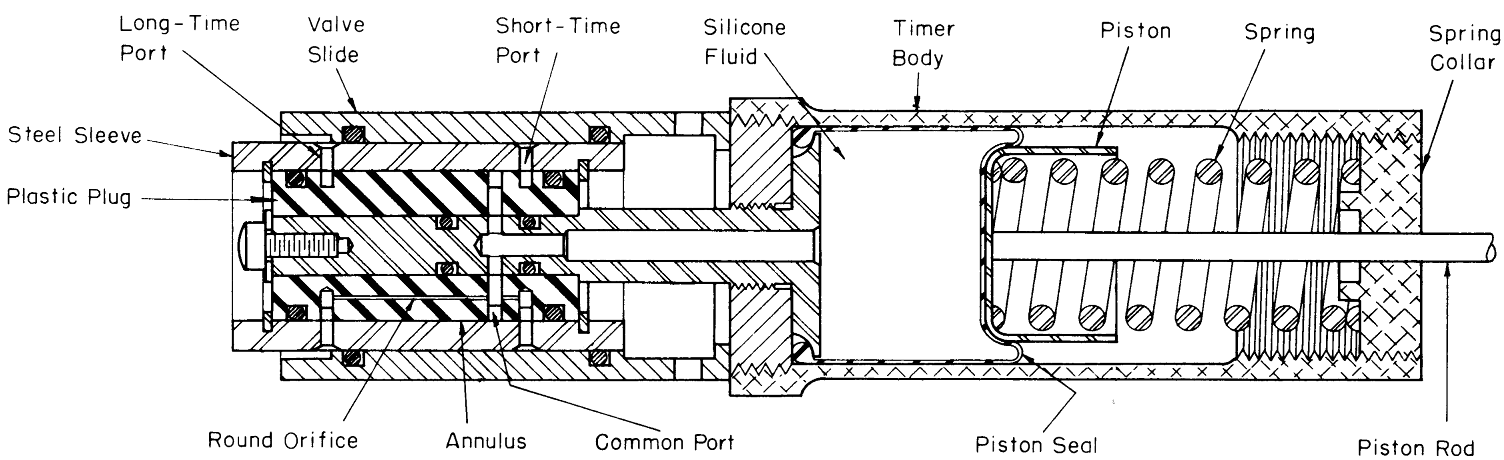

FIGURE 4. LABORATORY MODEL OF SILICONE-FLUID TIMER (SET FOR LONG-TIME OPERATION)

Evaluation

After this laboratory model was fabricated and assembled, it was evaluated at temperatures of -20, 50, and 120 F in the controlled-temperature chambers which had been built in the course of the original Task Order No. J effort. The flow was determined by accurate measurement of the travel of the piston. A micrometer head was set up within the temperature chamber, and an attached rod was arranged to extend from the head out through the temperature-chamber wall. When the rod was turned, the micrometer was turned, and the resulting contact with the piston was signaled by the closing of a low-voltage circuit.

The results of the evaluation are shown in Figure 5. By computation of the average flow rate at each temperature and comparison of each of these values with the extremes, it was found that the flow rate varied by ±14 per cent. Since one of the requirements was to maintain the flow rate within ±10 per cent, it was obvious that the laboratory model required some change in the temperature compensator.

A consideration of the possible sources of error in the laboratory model showed that the greatest possibility lay in an improper clearance between the parts forming the annulus. This could have been caused by a change in dimension of the plastic plug or by nonconcentric positioning of the plastic plug in the steel sleeve. After some deliberation, it was decided that the test results were good enough to warrant the design and construction of an experimental model of the timer. As a part of the new design, however, a means of adjusting the amount of radial clearance in the annulus was to be provided so that above-described types of errors could be eliminated.

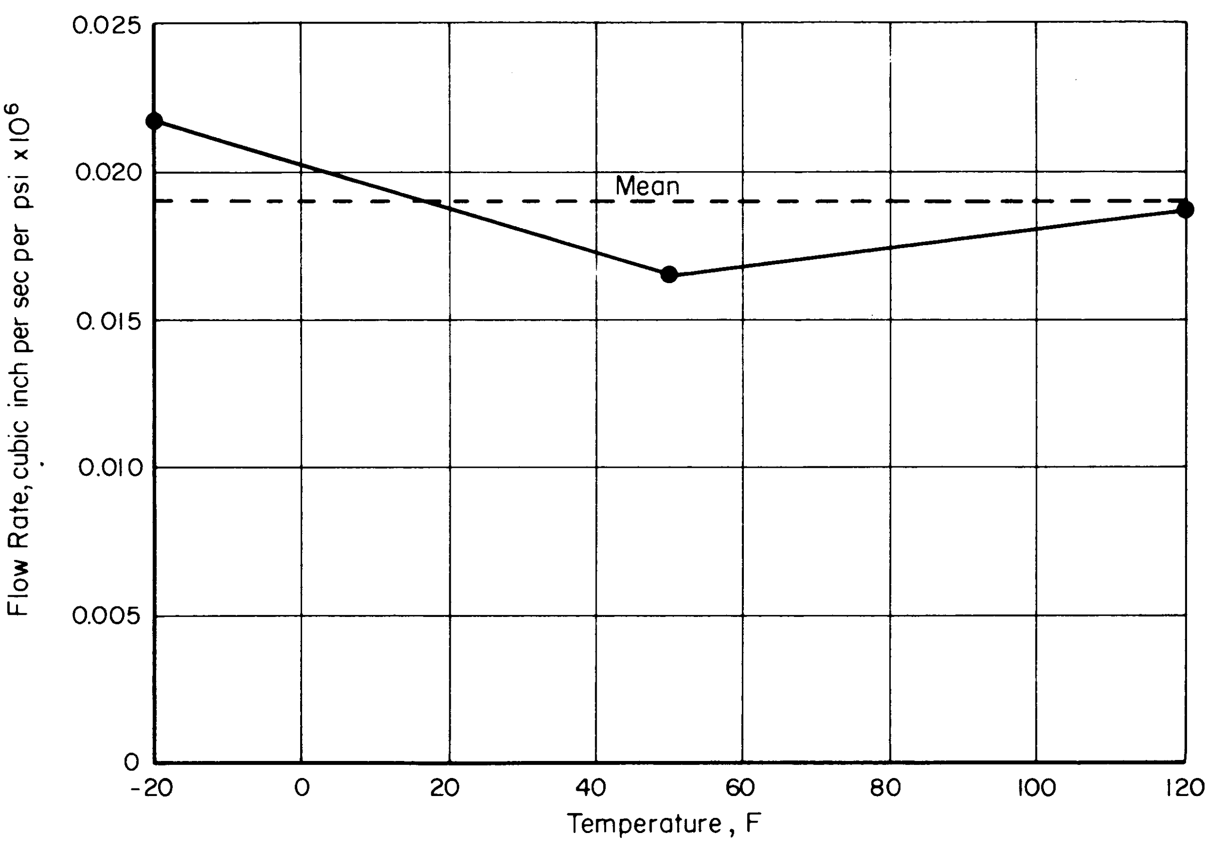

FIGURE 5. FLOW THROUGH LABORATORY MODEL OF TIMER AT -20, 50, AND 120 F

Experimental Model of Silicone-Fluid Timer

Design

The design of the experimental model of the silicone-fluid timer is shown in Figure 6. It will be noted that the valving end is quite similar to that of the laboratory model. The main differences were that the experimental model incorporated a tapered plug which could be shimmed to attain proper clearance in the annulus, and also a time-setting valve which could be used to "dump" excess fluid when short-time settings were desired. The operation of the valve slide and the two sets of orifices was essentially the same as in the laboratory model.

On the spring end of the device, a time-setting and firing mechanism was incorporated. Two springs were used; for short-time settings, a heavy spring with a short travel was provided, and for long-time settings, a light spring with a long travel was used. The springs were supported by the spring retainer, which was connected to a threaded collar on the outside of the device by a spider. The piston was restrained and also connected to the spring retainer by a safety pin; removal of the safety pin permitted pressure to be applied to the fluid. When the valve slide was positioned so that the fluid could flow, the piston would move under spring force. Both springs would push the piston for the first 3/8 inch of travel; after this amount of travel, the heavy spring would be completely expanded, and the light spring would continue to move the piston at a low rate.

To achieve short-time settings, some fluid would first have to be removed from the device. This would be done by opening the time-setting

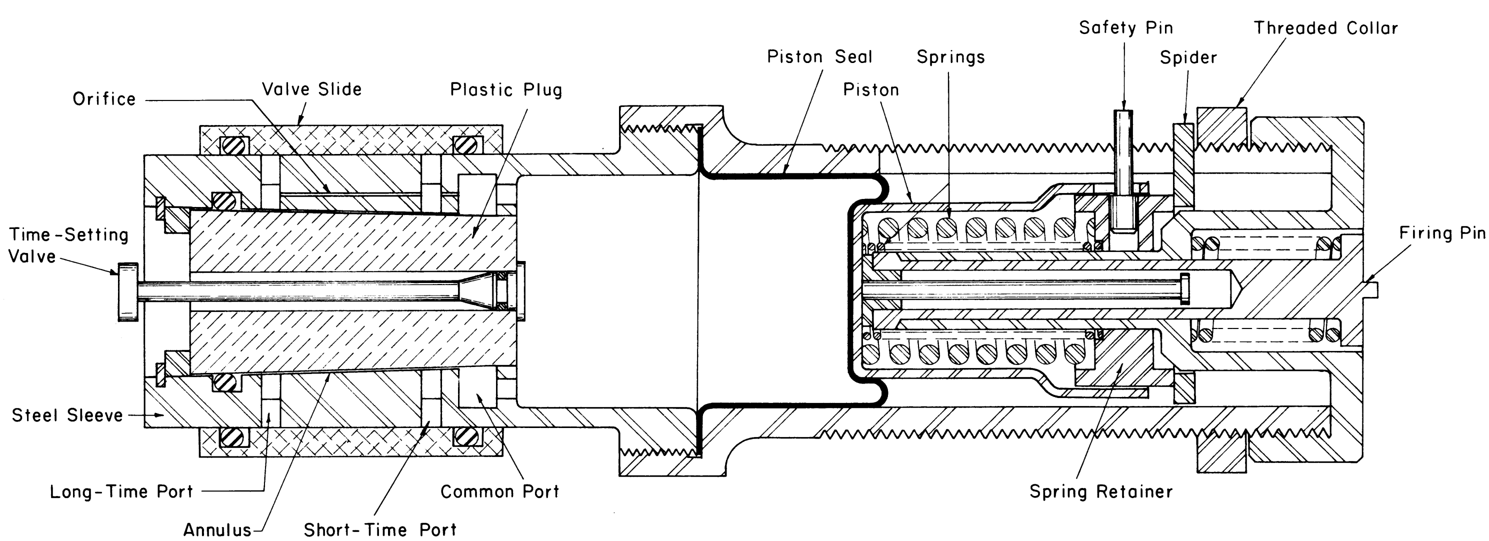

FIGURE 6. EXPERIMENTAL MODEL OF SILICONE-FLUID TIMER (SET FOR NO FLOW)

valve and then moving the piston to the left (in Figure 6) by turning the threaded collar before pulling the safety pin. This step of the procedure would not have to be used in setting for long-time delays.

After the device was set, it would be activated by removing the safety pin and sliding the valve slide to the right or left. Sliding the valve slide to the left would permit flow through the short-time port; sliding the valve slide to the right would permit the fluid to flow through the long-time port. Markings provided on the outside of the device would enable the operator to select the proper setting.

Evaluation

By the time the experimental model was fabricated and set up for evaluation, most of the funds were expended. Thus, we were able to conduct only a few short evaluatory experiments.

Unfortunately, these cursory tests did not indicate satisfactory performance; the flow obtained was quite low. Despite adjustments to the plastic plug, it was not possible to change the flow appreciably. When the unit was dismantled, it was found that a modification which had been made to permit easy filling of the unit for experimental purposes had resulted in the plastic plug expanding sufficiently to close off the annulus. However, the flow was so low that, in addition, trouble with the orifice was indicated.

During a discussion of the test data with the Sponsor, it was agreed that three steps should be followed in a further investigation of this design:

(1) The silicone fluid should be extruded through the orifice with dimensions as calculated, in order to verify the calculated flow rate.

Since the behavior of this fluid is not understood completely, it is possible that the equation for flow through the orifice (0.007 inch in diameter) would not be the same as that for flow through 1/16-inch-square ports as developed during the original work under Task Order No. J.

(2) A fixture should be made of steel to provide an annulus with dimensions as calculated, and the flow rate through this annulus should be checked.

(3) When the calculated flow rates through these two ports had been proven out experimentally, the combined orifice-annulus combination of the experimental unit should then be tested again. Preparatory to these tests, however, the design would have to be modified somewhat to provide more assurance of the concentric location of the plastic plug in the steel sleeve and of more stability of the outside diameter of the plastic plug.

After these three steps had been taken successfully, experimentation with the complete timer could then be undertaken.

Although the above-indicated further research did not appear to involve a large amount of additional funds, the Sponsor indicated that the requirement for a timer of this type did not justify further expenditures at that time. Furthermore, an impending project on a more simple silicone fluid timer was expected to provide pertinent valuable information with regard to the question underlying Step 1 above.

FUTURE WORK

Future work on this timer design was postponed at least until results from a development effort on a relatively simple timer became available. On March 27, 1959, Work Order No. IX, Task Order No. CC, was undertaken to develop a simple silicone-fluid timer which was expected to incorporate a fixed orifice length without a temperature compensator, and without springs and a rubber boot similar to those involved in the Task Order No. J experimental model.

SECRET

CONFIDENTIAL

CONFIDENTIAL

SECRET